APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: RENDERING A THREE-DIMENSIONAL MODEL USING A
DITHER PATTERN

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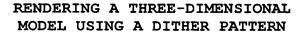
RENDERING A THREE-DIMENSIONAL
MODEL USING A DITHER PATTERN

TECHNICAL FIELD

5   This invention relates to rendering a three-dimensional

(3D) model using a dither pattern.

BACKGROUND

A 3D model may be defined using 3D volumetric data.   3D

10   volumetric data defines characteristics of models or "objects"

in a 3D environment.   For example, a 3D environment may

include a cloud.   3D volumetric data may be used to define the

density of regions of that cloud using dots or other elements.

15   ## DESCRIPTION OF THE DRAWINGS

Fig. 1 is perspective view of a 3D environment.

Fig. 2 is a perspective view of volumetric data in an

object from the 3D environment.

Fig. 3 is a flowchart for rendering a 3D model using one

20   or more dither patterns.

Fig. 4 is a block diagram of computer hardware on which

the process of Fig. 3 may be implemented.

DESCRIPTION

Fig. 1 shows a 3D environment 10 rendered using 3D data. 3D environment 10 includes a cloud 12. Referring to Fig. 2, the 3D data for cloud 12 is 3D volumetric data. That is, the

5   data defines which pixels are "on" or "off" in the 3D space occupied by cloud 12. In this way, the 3D volumetric data approximates the density of the cloud, i.e., more pixels "on" means higher density, fewer pixels "on" means lower density.

Although density is described here, it is noted that

10   volumetric data is not limited to defining an object's density. Volumetric data may be used to define any characteristic of a 3D model. For example, volumetric data may be used to define color in the three-dimensional model, field strength (e.g., electrical or magnetic) in a 3D model,

15   temperature in the 3D model, and/or pollution concentration in the 3D model.

Referring to Fig. 3, a process 20 is shown for rendering a 3D model, such as cloud 12, using 3D dither patterns. Process 20 receives (22) 3D data for 3D model 12. The data

20   may be retrieved from a memory, downloaded from a network, or obtained from any available source. The following describes rendering cloud 12 using 3D dither patterns; however, it is noted that process 20 may be used to render any object in 3D

environment 10 using dither patterns (provided, of course, that the object has associated volumetric data).

Process 20 selects (24) a 3D region of cloud 12. In this embodiment, process 20 selects a cubic region; however, any

5   type of 3D region may be used. Irregularly shaped regions may be used, particularly for regions near the boundary of cloud 12. Process 20 obtains (26) a characteristic of the selected region. As noted, the characteristic, in this case density, is defined by volumetric data associated with the selected

10 region. Process 20 obtains (26) the characteristic of the selected region as follows.

Process 20 selects (28) a sub-region of the selected region. The sub-region may be of any shape (e.g., a cube) and any size (e.g., from a single pixel to multiple pixels).

15 Process 20 obtains (30) the desired characteristic, in this case density, of the sub-region. The density is obtained from volumetric data for the sub-region. Process 20 determines (32) if there are any sub-regions for which the density has not been obtained. If so, process 20 repeats blocks 28, 30

20 and 32 until the density has been obtained for all sub-regions of the region selected in 24. Once the density has been obtained for all sub-regions, process 20 averages (34) the

values of the densities. The resulting average is assigned to
be the density of the selected region.

Process 20 determines (36) a dither pattern for the
selected region based on the density of the selected region.

5   In this embodiment, the dither pattern is defined by data
specifying pixels to illuminate in 3D space when rendering
cloud 12. The pixels define individual points (or dots) in
the dither pattern. The number and locations of the points in
the selected region are based on the density of the region.

10   That is, the higher the density, the greater the number of
points that are included in the selected region. The points
may be distributed randomly throughout the selected region to
approximate the density, or they may be distributed evenly.
The distribution may determined at the time of rendering,

15   i.e., "on-the-fly", or it may be pre-set. Alternatively, the
dither pattern may be selected from a set of pre-stored dither
patterns that correspond to various densities.

Once process 20 determines (36) the dither pattern for
the selected region, it is determined (38) if there are any

20   regions remaining in cloud 12. That is, process 20 determines
(38) if dither patterns have been selected for all regions of
cloud 12. If not, process 20 repeats blocks 24, 26, 36 and 38
until dither patterns have been selected for all regions.

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Once the dither patterns have been selected, process 20 outputs the dither patterns to a 3D graphics rendering process. The output may be a list of points that comprise the dithered approximation of the volumetric data for cloud 12.

5   The rendering process, which may or may not be part of process 20, renders (40) the 3D object, i.e., the cloud, using the dither patterns. The resulting rendering is a 3D object that approximates its density with concentrations of dots.

Fig. 4 shows a computer 42 on which process 20 may be

10   implemented. Computer 42 includes a processor 44, a memory 46, and a storage medium 48 (see view 50). Storage medium 48 stores 3D data 52 for 3D environment 10 and machine-executable instructions 54 that are executed by processor 44 out of memory 46 to perform process 20 on 3D data 52.

15   Although a personal computer is shown in Fig. 4, process 20 is not limited to use with the hardware and software of Fig. 4. It may find applicability in any computing or processing environment. Process 20 may be implemented in hardware, software, or a combination of the two. Process 20

20   may be implemented in computer programs executing on programmable computers or other machines that each include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage

components), at least one input device, and one or more output

devices. Program code may be applied to data entered using an

input device (e.g., a mouse or keyboard) to perform process 20

and to generate output information.

5   Each such program may be implemented in a high level

procedural or object-oriented programming language to

communicate with a computer system. However, the programs can

be implemented in assembly or machine language. The language

may be a compiled or an interpreted language.

10   Each computer program may be stored on a storage medium/

article (e.g., CD-ROM, hard disk, or magnetic diskette) that

is readable by a general or special purpose programmable

computer for configuring and operating the computer when the

storage medium or device is read by the computer to perform

15   process 20. Process 20 may also be implemented as a machine-

readable storage medium, configured with a computer program,

where, upon execution, instructions in the computer program

cause a machine to operate in accordance with process 20.

The invention is not limited to the specific embodiments

20   described above. Other embodiments not described herein are

also within the scope of the following claims.

What is claimed is: